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This report provides the Design Criteria for the Automotive Test Rig (ATR). The ATR is a 14 ton tracked Amphibious Test Vehicle to demonstrate the feasibility of hardware components. The ATR incorporated a retractable hydropneumatic suspension, wire link band track, two speed final drive, hydraulic drive train, and digital computer controller.

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ATR Design Criteria

Table of Contents

1.0 Introduction

This report presents the design criteria for the Automotive Test Rig (ATR) program. Major areas of criteria presented herein include Structural Design Criteria (Section 2.0), Environmental Design Criteria (3.0), Performance (4.0) and Weight Criteria (5.0). Every effort should be made to conform to these guidelines during design of the ATR. Should new or modified criteria evolve during the development of this vehicle, these criteria will be published as a revision to this report.

2.0 Structural Design Criteria

Unless otherwise specified, all loads given in this section are ultimate design loads at which breakage of parts is expected to occur. The magnitude of these loads includes a 1.5 factor of safety. Thus, the maximum applied loads are 67 percent of the ultimate design loads given (see following Section 2.1).

For purposes of calculation, gross vehicle weight is 28,000 pounds.

2.1 Safety Factors

$$\text{Safety Factor} = \frac{\text{Design Load}}{\text{Applied Load}}$$

Design Load - the theoretical failure load (1. material rupture, 2. inelastic failure and collapse, or 3. intolerable permanent deformation.)

Applied Load - the static or dynamic (including dynamic magnification) load

2.1.1 Required Factor of Safety Against Permanent Deformation = 1.0

2.1.2 Required Factor of Safety Against Ultimate Failure (unless otherwise specified)

2.1.2.1 Most Materials and Fabrication Methods - 1.5

2.1.2.2 Castings - 2

2.1.2.3 Castings (with X-ray, close quality control and minimum elongation of Seven Percent) - 1.5

2.2 Allowable Material Stresses

The allowable material or component stress used in design calculations shall be based upon specified minimum material strength values given in MIL-HDBK-5A or other material references.

Minimum full strength and welded mechanical properties for 5083 aluminum alloy armor are given in Table 1. The heat affected zone of welded joints shall be considered to extend to one inch from the joint.

Table 1 Minimum Mechanical Properties of 5083 Aluminum Armor

	Tensile Strength (psi)	Yield Strength (psi)	Elongation (% in 2")
Structural Members[1]			
0.5" to 2.0" incl.	45,000	37,000	8
2.001" to 3.0" incl.	44,000	35,000	9
Welded Joints[2]			
0.5" to 2.0" incl.	40,000	33,000	
2.001" to 3.0" incl.	39,000	31,000	

[1] Data from MIL-A-46027F (MR)
[2] Using 5356 filler wire

2.3 Road Loads

The road loads criteria were derived by a semi-empirical procedure given in "Automotive Bodies and Hulls, Engineering Design Handbook, "AMCP 706-357, 1970. Load factors determined were based upon a gross vehicle weight of 28,000 pounds and the curve for tracked combat vehicles ($n = 180W^{-0.156}$, see Figure 4-2 of Ref. 1).

2.3.1 Suspension

All vertical and fore-aft loads are applied on the centerline of the track.

2.3.1.1 Road Wheels (Loads Applied Independently)

Front Wheels - 102,000 lb. applied vertically upward to each wheel.

Remaining Wheels - 51,000 lb. applied vertically upward to each wheel.

All Wheels - 14,000 lb. applied laterally against bottom edge of road wheel in either direction.

2.3.1.2 Wheel Suspension Hydropneumatic Units (Loads Combined)

All Wheels - 16,800 lb. applied vertically upward combined with 8,400 lb. applied laterally against bottom edge of road wheels in either direction.

2.3.1.3 Idler Wheels

Radial Load - 153,000 lb. directed horizontally rearward, 153,000 lb. directed vertically upward, applied independently.

Combined Vertical and lateral load - 8,400 lb. applied vertically upward combined with 4,200 lb. applied laterally against the edge of the idler in either direction.

2.3.1.4 Track Support Rollers (Loads Applied Independently)

Radial Load - 8,400 lb. applied vertically on the centerline of the roller assembly.

Lateral Load - 4,200 lb. applied laterally against edge of roller in either direction.

2.3.1.5 Final Drive and Sprockets

Torque Load - 75 percent of total drive train output torque times 1.5 safety factor applied to a single sprocket tooth. Tooth wear should be considered.

Radial Load - 71,000 lb. applied on the centerline of each sprocket hub.

Combined Load - 8,400 lb. applied radially to the hub combined with 4,200 lb. applied laterally at O.D. of tooth in either direction.

2.3.2 Hull, Turret, and Vehicle Mounted Components (Loads Applied Independently).

Vertical Load - shock factor depends upon the weight and longitudinal location of the item under consideration and should be determined from Figure 1.

Longitudinal Load - 9 times the static weight of item.

Side Load - 7.5 times the static weight of item.

2.3.2.1 Engine, Hydrostatic Drive and Final Drive Mounts

Vertical Load - 4.5 times the static weight of item

Horizontal Load - 4.5 times the static weight of item

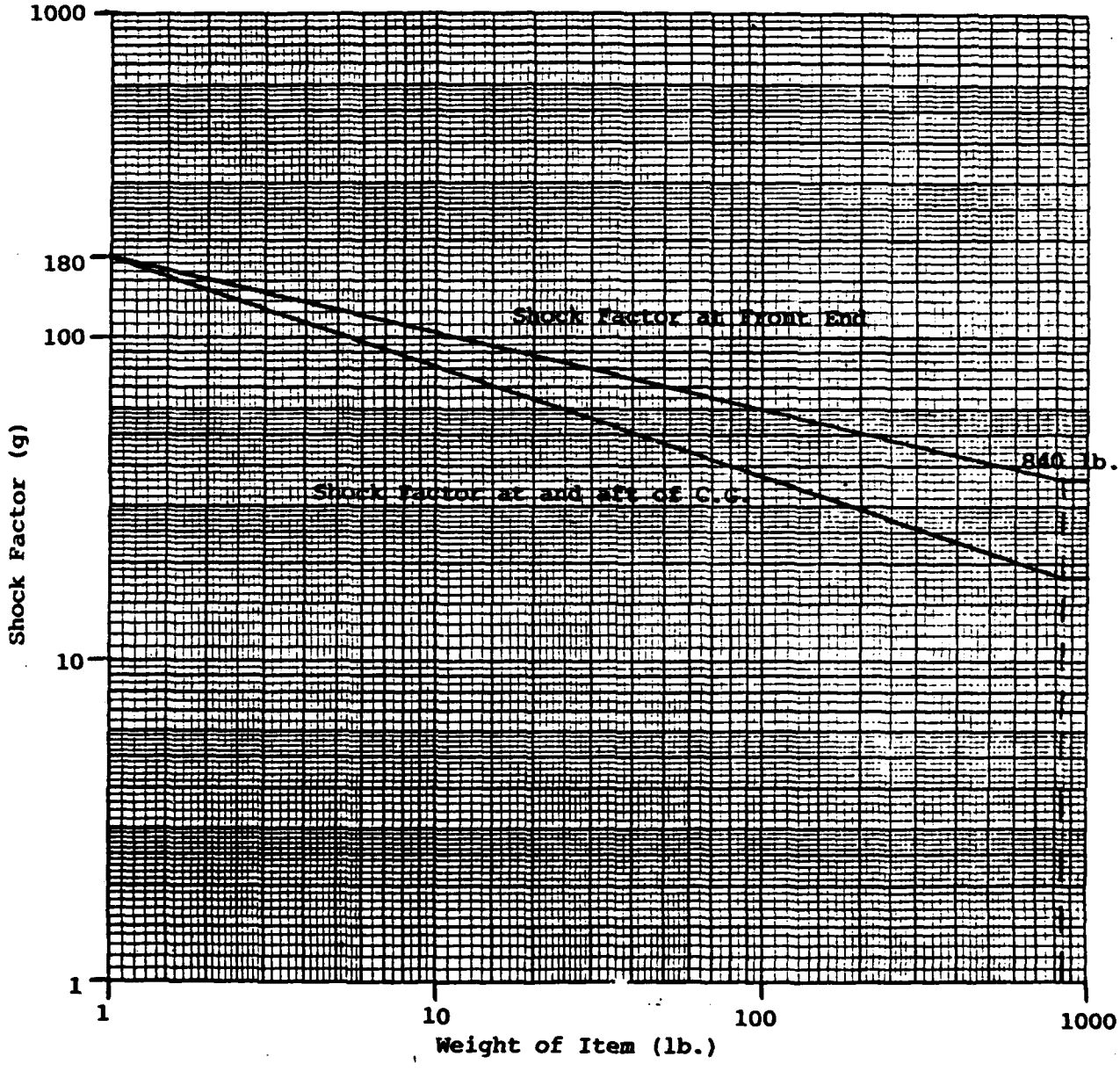

Figure 1. Road Shock Design Factors for Hull, Turret and Vehicle Mounted Components

2.3.2.2 Tow Hooks and Pintles

A static equivalent ultimate load equal to the gross vehicle weight (28,000 lb.) applied at any position within a 120° cone with the horizontal axis times a safety factor of 5.

2.3.3 Operational Durability

Those items standard to the vehicle will be designed for 6,000 miles of operation before requiring depot maintenance (i.e., that maintenance which is required for repair of material that requires a major overhaul or complete rebuilding of parts, subassemblies, assemblies, or the end item, as required). This criterion will not be required of any component placed on the vehicle for the purpose of government testing.

2.4 Hull Structure

2.4.1 Structural Loads

The hull structure will be designed to withstand the following loading conditions:

- o The torsional load incurred when the vehicle is supported by two diagonally opposite roadwheels located in the #1 and #5 roadwheel positions.
- o All loads imposed on the hull resulting from the road loads detailed in Section 1.3.
- o All loads imposed by the firing the the 25mm weapon, detailed in Section 1.5, below, combined with a 3 g vertical road load applied to the turret and weapon components.
- o The wear imposed on the sponsons and hull side due to track slap.
- o The loads induced when the vehicle is supported by the #3 roadwheels. The roadwheels at station #3 will be considered as bottomed out against the sponson, with no other roadwheels contacting the ground, for this analysis.

2.4.2 Watertightness

All joints and access doors will be waterproof.

2.4.3 Floor Structure

The floor structure will be designed to safely support all equipment and personnel loads placed on it, in addition to the bending and torsion loads imposed on it by the suspension system.

2.5 25mm Weapon Firing Loads

2.5.1 Recoil Load - 7000 lb. (recoil force) times 2.0 (dynamic load factor)* = 14,000 lbs (normal applied load), times 1.5 (safety factor) = 21,000 lbs (equivalent static ultimate load applied at the trunnion centerline).

2.5.2 Counterrecoil Load - The counterrecoil force of the 25mm gun has not, as yet, been determined. Following its determination, this criteria will be utilized if it is deemed critical.

2.5.3 Fatigue Design - Firing rate of gun is up to 200 rounds per minute. All support structure should permit 100,000 gun firing cycles without failure. All replaceable components should permit 20,000 gun firing cycles without failure. Fatigue design firing load will be the equivalent static ultimate load of Section 2.5.1, above.

2.6 Transportation Loads

Transportation of the vehicle will be accomplished via truck. The requirements for this type of transportation are outlined in MIL-HDBK-157. The loads encountered in highway transportation will not exceed the structural design loads described above.

2.6.1 Tie Downs and Lifting Eyes

Tie downs and lifting eyes will be designed per MIL-STD-209E.

2.7 Human Factors Applied Loads

2.7.1 Foot Operated Controls - 750 lb.

2.7.2 Hand Operated Push-Pull Controls - 150 lb. fore or aft, 75 lb. side

2.7.3 Seats - 1,800 lb. in any direction

2.7.4 Steps - 525 lb. vertical

3.0 Environmental Design Criteria

3.1 Operating Temperature Range - Operable at 20°F to 110°F ambient.

3.2 Salt

Vehicle will be operable after 48 hour exposure to atomized 5 percent salt solution, 95°F ambient temperature. Also, vehicle structure will not be adversely effected by prolonged exposure to a saltwater environment.

* As the mounting characteristics of the weapon have not been determined to date, a maximum possible value has been used.

3.3 Other Environmental Factors

Operable after exposure to moderate amounts of rain, dust, or sand or to extremes of humidity.

3.4 Water Immersion

Operable during and following complete submersion in water.

3.5 Vibration

Vibrational inputs:

Track induced - 0 to 118 hz

Armament induced - 1 to 3.33 hz.

4.0 Performance

4.1 Gradeability and Side Slopes

Longitudinal - up to 60 percent on smooth, dry concrete

Side - up to 40 percent

Climb and descend

Stable

No spillage or leakage of fuel, lubricants, or other fluids

No fuel, lubricant starvation

Brake holding capability (service and parking)

4.2 Maximum Forward Speed - 40 mph

4.3 Terrain

Capable of operating in and overriding dense brush and trees of up to three inch diameter (a 500 lb. force is estimated as necessary to override a three inch diameter tree).

4.4 Waterborne Performance

Capable of operating in light to moderate seas without being adversely effected by pitch and roll resulting from wave action.

4.4.1 Maximum Forwad In-Water Speed - 6 mph.

5.0 Weights Criteria

A primary requirement of the ATR program is that the vehicle weight be maintained at 28,000 pounds. The weight of components placed on the vehicle will be closely monitored in order to meet this criteria.